Subtypes of learning disabilities: neuropsychological and behavioural functioning of 495 children referred for multidisciplinary assessment

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Abstract Aim of the present study was two fold: (1) to evaluate the course of referring and diagnosing Learning Disabilities (LD) and the contribution of multidisciplinary assessment and (2) to describe characteristics of three LD subtypes: Attention with or without Motor function Disabilities (AMD), Verbal Learning Disabilities (VLD) and Non-Verbal Learning Disabilities (NVLD). Diagnostics, behavioural and neuropsychological data from 495 children aged 6–17 years were described. First, AMD and VLD was the most frequent LD. Multidisciplinary assessment could contribute to the diagnostic process of LD, especially in diagnosing uncommon LD and comorbidities. Secondly, behavioural ratings, information processing, attention regularity and visual-motor integration proved to be most sensitive in discriminating between the three LD subtypes. However, diagnosing NVLD requires additional developmental information. Multiple discriminant function analysis correctly classified 61.7% of a selection of the present sample into LD subtypes as diagnosed by the multidisciplinary team. It is believed that the three subtypes are clinically relevant and suggestions are made to test the present classification functions in an independent sample, preferably diagnosed using a structured diagnostic interview.

Key words learning disabilities – subtypes – neuropsychology – behavioural functioning – children

Introduction

Learning disabilities (LD) affect about 1–2.5% of the general population and 10–15% of school-aged children [2, 16]. LD frequently occurs together with behavioural, social and emotional problems [15]. A variety of definitions can be found in the research literature, representing various problems and underlying causes. Four conceptual elements are common in most definitions of LD: (1) heterogeneity, (2) neurobiological nature, (3) discrepancy between learning potential and academic performance and (4) exclusion of sensory or motor impairments, mental retardation, emotional disturbance or environmental, cultural or economic disadvantages as causes of LD [20, 26]. Furthermore, the learning problems should interfere with school performance and/or daily functioning [2].

Two subtypes of LD are extensively reported in the literature: Verbal Learning Disabilities (VLD) and Non-Verbal Learning Disabilities (NVLD) [11, 21]. The VLD subtype is characterized by relative deficits

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in language skills (e.g. dyslexia and Specific Language Impairment (SLI)) [5, 18]. Conversely, children with NVLD have impaired visual-spatial abilities (e.g. dyscalculia and Nonverbal Learning Disorder (NLD)) [13, 32]. In addition, attention deficit disorders are frequently shown to be the primary diagnosis in children referred for LD [9, 27, 41]. Therefore, attention disorders can be distinguished as a LD subtype next to the subtypes VLD and NVLD. In this study, attention disorders were described as an umbrella category, named Attention with or without Motor function Disabilities (AMD), because 50% of the children with attention disorders also experience motor problems [3, 30]. Examples of specific LD in the AMD subtype are: attention deficit hyperactivity disorder, combined type (ADHD-C), deficits in attention, motor control and perception (DAMP) and developmental coordination disorder (DCD) [2, 31].

LD frequently lead to secondary problems such as low self-esteem, behavioural problems, dropping out of school and social problems [16]. Early diagnostics and intervention are of great importance, because of the aforementioned secondary problems associated with LD. It has been argued that a multidisciplinary approach is the best way to achieve this [9, 29]. However, only six studies have reported empirical data on children evaluated in such multidisciplinary LD clinics [7, 9, 27, 32, 39, 41]. The main conclusion in reviewing these six studies is that children with LD represent a heterogeneous group predominated by boys. ADHD, reading and arithmetic disorders are the most frequent diagnoses. Furthermore, the majority of children have multiple diagnoses.

The present study describes data of a large sample of 495 children referred to a specialized LD clinic. Our aim was two fold: (1) to describe the course of referring LD, diagnosing LD and the contribution of multidisciplinary assessment and (2) to verify whether the three subtypes AMD, VLD and NVLD described in the literature were encountered in a clinical sample by describing the behavioural and neuropsychological functioning of children with LD.

Method

Procedure

All children referred to the LD clinic at the Maastricht University Hospital in the period January 2001–2005 were included. The multidisciplinary team in this specialized, tertiary centre consisted of child neuropsychologists, a child neurologist and a youth health care physician. In case of comorbid psychiatric problems such as pervasive developmental disorders, children were also referred to the child psychiatrist. The assessment protocol included a neurological examination, evaluation of general health and psychological data [17]. Psychological data were obtained from three sources: (1) interview with parents, (2) battery of neuropsychological tests and (3) behaviour questionnaires completed by parents and teachers. Diagnoses were made according to the diagnostic criteria of the DSM-IV TR. There is one exception to this rule: not all distinguished LD subtypes are described in the DSM-IV TR, consequently ‘DAMP’ is diagnosed combining the DSM-IV TR ADHD and DCD criteria [2, 14] and ‘NLD’ is diagnosed according to the neuropsychological and developmental criteria of Rourke [32]. The study was approved by the local medical ethics committee.

Participants

About 61 children were excluded based on the following criteria: (1) age below 6 ($N = 30$), (2) primary sensory deficit ($N = 1$), (3) use of psycho stimulants ($N = 17$) and (4) information processing capacities equal to or lower than 70 ($N = 13$). The clinical reports of 495 children (366 boys; 129 girls) were analysed; mean age 10.03 years (SD = 2.54), with a range from 6.01 to 17.47 years. The distribution of social economical status was 13.1% low, 34.7% middle and 40.0% high. In 12.1% of the cases this information was missing. Most children originated from the southern part of the Netherlands.

Measures

The standardized neuropsychological test protocol emphasized on cognitive functioning, included examinations of information processing, language skills, memory, attention and visual motor integration [24, 32]. Depending on the referral question, academic tests were administered as well.

The *Kaufman Assessment Battery for Children* (K-ABC) measures information processing and utilizes two component processes, namely sequential and simultaneous processing. The K-ABC yields standard scores for sequential, simultaneous and total information processing (mean = 100; SD = 15). Scores were calculated according to the German standard. The reliability of the three scales is high ($r = 0.88$–0.93) and additionally, validity of the K-ABC is supported by a fairly high correlation with the WISC-R ($r = 0.70$) [28, 31].

Riddles of the K-ABC is an achievement subtest that measures language reasoning. A child is asked to discover a concept when only some characteristics are mentioned in the form of a riddle (mean = 100;

SD = 15). Again, German standards were used and split-half reliability is high (r = 0.81) [23, 28].

The Dutch version of the *Rey Auditory Verbal Learning Test* (RAVLT) is a learning and memory test. About 15 words are presented for five trials. After every trial (immediate recall) and 15 min after the last trial (delayed recall) the child is asked to reproduce the memorized words. Outcome is the total number of correctly reproduced words (mean = 50; SD = 10) [12, 36].

The *Bourdon-Vos test* (BV) is used to measure visual sustained attention. The BV is a paper-and-pencil cancellation test that consists of 33 lines with each containing 24 figures made of dots. The child is asked to mark all figures with four dots as fast and as accurately as possible. Outcome measures are the speed (mean line time) and accuracy (number of omissions, commissions and corrections) (mean = 0; SD = 1). Regularity of working is represented on a 3-point scale (−1 = irregular, 0 = regular, 1 = highly regular) [12, 40].

Symbol-digit task is a subtest of the Wechsler Intelligence Scale for Children—Revised (WISC-R) used to measure automation in the visual channel. The child is asked to fill in symbols corresponding to certain forms or digits (mean = 10; SD = 3) [8, 12].

The *Beery Developmental Test of Visual Motor Integration* (VMI) is used to measure the integration of visual perceptual and fine motor abilities. The child has to copy 24 geometric forms that increase in difficulty (mean = 100; SD = 15). American standards were used. The reliability is high ($r = 0.92$) and additionally, validity is supported by fairly high correlations with concurrent tests [4].

The *One-Minute-Test* (In Dutch: '*Een-Minuut-Test*'; *EMT*) and the *Klepel* are standardized Dutch reading tests. The child is asked to correctly read aloud as many words and non-existing words as possible, respectively (mean = 10; SD = 3) [6, 12, 35].

Arithmetic of the WISC-R is used to measure arithmetic performance. Arithmetic problems are read to the child, who is expected to provide an answer without using scrap paper (mean = 10; SD = 3) [8, 12].

The *Child Behaviour Checklist* (CBCL) and the *Teachers Report Form* (TRF) measure general pathology and have been demonstrated to be useful in detecting children with and without behaviour problems. The CBCL and TRF both yield T-scores for a Total problem scale and for two broadband scales (Externalising and Internalising behaviour). It also yields T-scores for nine subscales, one of which (Attention problem subscale) was used in the present study (mean = 50; SD = 10) [1, 12, 34, 37, 38].

The *Social Economical Status (SES)* is based on the education level of caregivers and was scored on an 8-point scale, ranging from primary education to post-university education [10]. When the SES differed between mother and father, the highest score was chosen. For the purpose of this study, this 8-points scale was recoded into the following groups: lower SES (scores 1, 2), average SES (scores 3, 4), and higher SES (scores 5, 6, 7 and 8).

The interview with parents is used to obtain information on the following domains; referral course, course of development, school, academic and present functioning [19]. The diagnostic criteria of developmental disorders according to the DSM-IV TR are inquired as well [2].

Data analysis

Differences in gender, SES and level of comorbidity between the LD subtypes were tested using χ^2 tests. Differences in age, behavioural functioning and neuropsychological scores between the three LD subtypes were tested using one-way analysis of variance with post hoc Tukey tests for Honestly Significant Differences (HSD). Multiple discriminant function analysis was performed on a selection of the present sample to predict LD subtypes. Selection criteria were: (a) scores on the K-ABC and (b) an AMD, VLD or NVLD diagnosis ($n = 189$). Furthermore, academic measures were excluded from this analysis, because not all children were examined academically. Missing data on the predictor variables were imputed by use of the Expectation Maximization algorithm through SPSS Missing Value Analyses [25]. On average, 15.0% (SD = 8.78) of the data were missing with a range from 0% (K-ABC) to 35.4% (regularity of attention). The selected sample was divided at random in two groups for split-half cross-validation. The first group ($N = 95$) was used for analyses and defining the discriminant functions. The second group ($N = 94$) was hold-out for validating the classification functions determined in the first group.

Results

Referral questions, diagnoses and the correspondence between them

Referral questions were formulated by several monodisciplinary health care services, such as neurologists (30.3%), youth health care physicians (23.6%), family doctors (6.3%) and paediatricians (5.1%). VLD and AMD were the most frequent reasons for referral and diagnoses (Table 1). Within these two main categories, dyslexia and ADHD-C had the highest incidence in the present sample. NVLD were diagnosed less frequently. In 10% of cases no diagnosis could be established. Notably, percentages

Table 1 Percentages of diagnoses and the correspondence with referral questions

Main and subcategories	Diagnoses % participants		Correspondence with referral questions (%)	
No diagnosis	10.3			
Attention with or without motor function Disabilities (AMD)	41.0		68.3	
Attention deficit hyperactivity disorder, combined type (ADHD-C)		25.7		74.0
Attention deficit hyperactivity disorder, inattentive type (ADHD-I)		5.5		29.6
Deficits in attention, motor control and perception (DAMP)		3.2		6.3
Developmental coordination disorder (DCD)		1.8		0
Remainder		6.3		0
Verbal learning disabilities (VLD)	51.7		81.6	
Dyslexia		40.0		73.7
Specific language impairment (SLI)		7.3		30.6
Remainder		6.9		23.5
Non-verbal learning disabilities (NVLD)	4.0		70.0	
Dyscalculia		1.2		50.0
Nonverbal learning disorder (NLD)		2.8		64.3
Remainder (i.e. organic, psychiatric, behavioural, social-emotional problems)	22.8			

may not add up to 100% because a child could have more than one diagnosis.

The percentage of children, for whom the eventual diagnosis was consistent with the referral question, was determined for each LD subtype (Table 1). Overall, the eventual diagnosis did not correspond with the referral question in 26.7% of cases, an average of the three LD subtypes. At the level of specific subtypes, less known and less frequently occurring diagnoses such as ADHD-I, DAMP, DCD and SLI had a clearly lower agreement between diagnosis and referral question, and were rarely reasons for referral. Alternatively, concerning the specific subtype NLD, compared to 2.8% of the children diagnosed with NLD, another 7.9% of the children were referred for NLD. However, these children were diagnosed otherwise, mostly with AMD or no diagnosis.

Due to co-morbidity, more diagnoses (671) were established than reasons for referral (557) had been indicated. About 31% of the children with a clinical diagnosis had at least one coexisting disorder. The percentage of at least one comorbidity differed between groups ($\chi^2 = 35.12$, $P < 0.000$) and was highest in the AMD group (59.6%). The most frequent comorbidity was the co-occurrence of AMD and VLD (14.5%).

Performance of LD subtypes on behavioural and neuropsychological measures

Children with co-occurring LD subtypes and/or comorbid neurological problems were excluded from the following analyses in order to compare pure LD subtypes. Table 2 gives an overview of descriptive and behavioural measures of the three LD subtypes. There were significant differences in gender and age between the LD subtypes. The LD subtypes did not differ in SES.

Additionally, there were differences in the prevalence of behavioural problems as measured with the CBCL and TRF between subtypes. The VLD subtype showed the fewest behavioural problems. Externalising problems were highest in the AMD group, whereas internalising problems, as rated by teachers, were enhanced in the NVLD subtype.

The performance of the LD subtypes on neuropsychological tests is shown in Table 3. Sequential information processing was significantly lower in the AMD than in the NVLD group. Simultaneous information processing was significantly lower in NVLD compared with the AMD subtype, which was in turn lower compared with the VLD group. The AMD subtype worked more irregularly than the VLD subtype on the sustained attention task, whereas accuracy and speed of working did not differ between the LD subtypes. Visual motor integration was significantly higher in the VLD group compared with subtypes NVLD and AMD. The VLD group scored significantly lower than the other two groups on both reading tasks. Moreover, the reading of non-existing words was worse in AMD compared with the NVLD subtype. Arithmetic performance was significantly worse in NVLD than in the AMD and VLD groups. The three LD subtypes did not differ in performance with regard to total level of information processing, language reasoning, auditory memory and symbol-digit tasks.

Finally, a multiple discriminant function analysis in the first half group revealed two significant functions, combined $\chi^2(12,\ N = 95) = 55.49$; $P < 0.000$. After removal of the first function, the second discriminant function retained a high degree of dis-

Table 2 Description of LD subtypes in terms of demographic and behavioural variables

	N per variable AMD/VLD/NVLD	(1) AMD (*N* = 127) Mean (SD)	(2) VLD (*N* = 180) Mean (SD)	(3) NVLD (*N* = 18) Mean (SD)	Test statistic	Tukey[a]
Gender (m/f)	127/180/18	104/23	112/68	12/6	13.87**, [b]	
Age (in years)	127/180/18	9.25 (2.78)	10.34 (2.11)	10.22 (2.53)	7.81**, [c]	1 < 2
SES (L/M/H)	118/46/15	18/55/45	19/59/68	2/2/11	7.91[b]	
CBCL T-scores[d]		Mean (SD)				
Total problem	111/95/17	64.66 (8.85)	58.39 (11.41)	59.06 (13.54)	9.84**, [c]	1 > 2
Internalising	112/95/17	58.64 (10.33)	57.67 (11.61)	59.76 (14.29)	0.35[c]	
Externalising	112/95/17	62.90 (11.28)	54.61 (11.84)	50.76 (13.04)	17.02**, [c]	1 > 2.3
Attention scale	119/95/17	70.56 (7.97)	62.23 (8.39)	67.53 (12.40)	25.28**, [c]	1.3 > 2
TRF T-scores[d]		Mean (SD)				
Total problem	100/87/16	65.29 (8.63)	55.75 (9.04)	61.88 (6.87)	28.14**, [c]	1.3 > 2
Internalising	100/87/16	56.50 (9.65)	53.98 (9.00)	63.75 (7.34)	7.90**, [c]	1.2 < 3
Externalising.	100/87/16	63.95 (9.66)	51.08 (10.60)	53.38 (7.01)	40.82**, [c]	1 > 2.3
Attention scale	108/87/16	69.26 (9.70)	58.69 (7.36)	62.00 (9.95)	35.13**, [c]	1 > 2.3

Note. AMD, Attention with or without motor function disabilities; VLD, Verbal learning disabilities; NVLD, Non-verbal learning disabilities; SES, Social economical status; L, Low; M, Middle; H, High; CBCL, Child behavior checklist; TRF, Teachers report form

[a] Post hoc Tukey's HSD, $P < 0.05$

[b] χ^2 test

[c] One-way anova $F_{(2,322)}$ test

[d] [1, 37, 38]

* $P < 0.05$; **$P < 0.01$

Table 3 Performance on neuropsychological tests for AMD, VLD and NVLD subtypes

	N per test AMD/VLD/NVLD	(1) AMD (*N* = 127) Mean (SD)	(2) VLD (*N* = 180) Mean (SD)	(3) NVLD (*N* = 18) Mean (SD)	*F*	Tukey[a]
Information processing	96/66/14	91.96 (9.28)	94.74 (9.04)	89.00 (10.41)	3.01	
Sequential	104/71/14	86.97 (12.06)	87.48 (11.42)	95.36 (10.40)	3.20*	1 < 3
Simultaneous	97/66/14	95.12 (10.88)	99.59 (11.32)	84.64 (13.05)	10.84**	2 > 1 > 3
Language	97/64/14	96.37 (11.24)	95.00 (13.07)	96.71 (10.48)	0.29	
Memory						
Immediate	92/154/14	51.16 (9.81)	51.77 (11.61)	51.50 (14.55)	0.04	
Delayed	91/153/14	48.14 (10.20)	50.18 (11.33)	51.07 (12.97)	1.12	
Attention						
Accuracy	88/145/16	−0.42 (1.12)	−0.13 (1.06)	−0.50 (0.97)	2.41	
Speed	89/145/16	−0.53 (1.05)	−0.46 (0.99)	−0.56 (0.96)	0.19	
Regularity	74/133/12	−0.70 (0.57)	−0.44 (0.63)	−0.67 (0.65)	4.79**	1 < 2
Symbol-digit	102/130/16	8.98 (3.76)	9.32 (3.20)	8.06 (3.32)	1.06	
Visual motor integration	109/152/18	90.08 (10.85)	96.40 (11.99)	83.56 (9.85)	16.41**	1.3 < 2
Reading word	37/42/8	8.49 (2.92)	4.21 (2.48)	10.13 (2.75)	32.30**	1.3 > 2
Reading pseudo	43/48/9	7.98 (2.30)	5.29 (2.05)	10.44 (2.88)	28.58**	3 > 1 > 2
Arithmetic	43/27/12	8.63 (2.62)	8.85 (2.91)	6.42 (2.64)	3.71*	1.2 > 3

Note. AMD, Attention with or without motor function disabilities; VLD, Verbal learning disabilities; NVLD, Non-verbal learning disabilities

[a]Post hoc Tukey's HSD

*$P < 0.05$; **$P < 0.01$

criminating power, $\chi^2(5, N = 95) = 16.49$; $P = 0.006$. The two discriminant functions accounted for 73.0% and 27.0% of the total variance respectively. The first function discriminated the AMD subtype from the VLD and NVLD groups. This function correlated substantially with four variables (TRF externalising ($c = -0.63$), regularity of attention ($c = 0.61$), visual motor integration ($c = 0.46$) and symbol-digit task ($c = 0.32$)). The second discrimination function separated the VLD subtype from the AMD and NVLD subtypes, corrected for the first function. Two variables (simultaneous processing ($c = 0.71$) and CBCL externalising ($c = 0.69$)) loaded on this function. Eight predictors were dropped from the model because of non-significance: sequential processing, immediate and delayed auditory memory, speed and accuracy of attention, language reasoning, CBCL and TRF internalising scales. This multiple discriminant function analysis yielded three classification functions, one for each LD subtype. These three classification functions were used to classify children in the second half group into one of the three LD subtypes. Overall, 61.7% of the children were correctly classified into the diagnosed LD subtype, compared with 39.9% chance classification. The AMD (68.8%) and VLD (56.8%) children were more likely to be correctly classified than the NVLD children (44.4%).

Discussion

We described a sample of 495 children referred for LD during a period of four consecutive years. The present sample of children with LD was dominated by boys (ratio 3:1), with a mean age of 10.03 years. This is in accordance with the literature [7, 27, 33]. The majority of parents of the present sample were educated to a medium or high level, which is also in line with previous findings [7, 27].

Overview of referral questions, diagnoses and evaluating multidisciplinary assessment

One out of 10 children referred on monodisciplinary basis proved to have no LD. VLD and AMD were the most frequent diagnoses, as has been reported by other authors [27, 39]. NVLD was diagnosed less frequently (2.8%), whereas other authors described a prevalence rate of 10% in a sample of children with LD [32]. Overall, in 26.7% of the cases the diagnosis did not correspond to the referral question from monodisciplinary health care services. Thus, multidisciplinary investigation of LD seemed to contribute to the diagnostic process, particularly for uncommon disorders. These uncommon disorders (ADHD-I, DAMP, DCD, SLI) were underrepresented in the reasons for referral, possibly because of a deficiency in specific knowledge about these disorders in monodisciplinary health care services. Conversely, NLD showed a referral trend and was overestimated when compared with the diagnoses made. NLD was often referred based on one or two characteristic(s), whereas more criteria need to be met for diagnosis according to Rourke [32]. Of the children referred for NLD, only 18.8% received this diagnosis. Furthermore, these data showed that more diagnoses were determined than reasons for referral had been indicated. In 31.3% of referred cases at least one coexisting disorder was established, which is one of the characteristic features of LD, i.e. heterogeneity [26, 39].

In conclusion, examination of children with LD by a specialized multidisciplinary clinic contributed to the diagnostic process compared with monodisciplinary assessment, particularly in diagnosing uncommon LD and determining comorbidities. However, poor referral patterns may have contributed to the differences as well. Future research should use a structured diagnostic interview to examine the reliability of the present findings.

Specific demographic, behavioural and neuropsychological profiles of LD subtypes

The three LD subtypes AMD, VLD and NVLD differed in gender and age: AMD children were younger at the time of assessment and more often male compared with the other two LD subtypes. Furthermore, the subtypes of LD showed different patterns of behavioural problems. Overall, the VLD group had the fewest behavioural problems. The AMD group was characterized by more externalising behavioural problems, such as attention problems, than the other subtypes. The NVLD group displayed more internalising behavioural problems compared with the other subtypes, but only if rated by teachers. These results confirm previous findings [22, 32].

Additionally, the three LD subtypes could be distinguished by differences in neuropsychological profile. A lower level of sequential processing and a more irregular speed of working on a sustained attention task characterized the AMD group. These results are partly in line with other studies reporting lower cognitive abilities and an increased variability in sustained attention tasks in children with attention disabilities [3]. As expected, the VLD group had lower scores on reading tasks [18, 32]. The level of visual motor integration was higher in VLD compared with the other subtypes. The NVLD subtype was distinguished by lower simultaneous processing and arithmetic performance, corresponding to earlier findings [32]. It can be concluded that the following subset of neuropsychological tests proved to be important in discriminating between the subtypes of LD: K-ABC, regularity of working on the BV, VMI, reading and arithmetic performances. Therefore, academic measures should be added to the standardized test protocol.

The multiple discriminant function analysis showed that it is possible to distinguish AMD, VLD and NVLD based on neuropsychological and behaviour measures. The percentage of children correctly classified (61.7%) is reasonable, albeit exclusively behavioural and neuropsychological measures were used to predict LD subtypes. Classification accuracy was better for the AMD and VLD group than for the NVLD group. Indeed, the classification accuracy for the NVLD group was only slightly above chance level.

This is possible due to the importance of the interview with parents about the developmental course in diagnosing NLD, which was not included in the discriminant function analysis [32]. The usefulness of this discriminant function analysis should be tested in an independent sample, preferably diagnosed according to a structured diagnostic interview.

Limitations

Several conceptual issues need to be considered in the light of the results presented here. First, LD subtypes were compared in terms of behavioural and neuropsychological functioning, while these variables were also part of the diagnostic process. However, diagnoses were made according to the diagnostic criteria of the DSM-IV TR. Multiple information sources contributed to this diagnostic process, so diagnoses were never based on behavioural and neuropsychological information alone. Second, these results may have been influenced by a referral bias, which limits generalization of the present findings. This sample may differ from the total population of LD in the degree of experienced problems, the need for help of parents and/or school and the referring policy of monodisciplinary health care services. However, we think the present sample is fairly representative because of the large sample size and the fact that the sample characteristics corresponded to other studies. Third, generalization of the present findings may be reduced by the used neuropsychological test protocol. However, neuropsychological tests are assumed to measure an underlying cognitive function and therefore, findings on cognitive functioning can be used to generalise to other populations. As the test protocol was determined at study start (2001), some examinations are inevitably growing outdated. Finally, academic measures were only available for a minority of children as they were not part of the standardized test battery, which may have influenced the results. Therefore, we have left these variables out in the discriminant function analysis. Future research to LD should add academic measures to the standardized test protocol.

Clinical implications

The present study is rather unique in reporting multidisciplinary evaluations of a large sample of children suspected of LD. The results demonstrated that AMD and VLD was the most frequent LD. Multidisciplinary assessment can contribute to the diagnostic process of LD, especially in diagnosing uncommon LD. The three subtypes AMD, VLD and NVLD can reasonably be distinguished in clinical samples based on behavioural and neuropsychological functioning. However, more information is necessary for diagnosing NVLD, which indicates the need for further research into this subtype. Further research should increased knowledge of the underlying problems of children with LD, which will enhance the early detection and management of these children and minimize the secondary consequences of LD.

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